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A SPECIAL REPORT:

THE UNITED STATES AIR FORCE

SCHOOL OF AEROSPACE MEDICINE

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Vice Commander

November 1989

USAF SCHOOL OF AEROSPACE MEDICINE
Human Systems Division (AFSC)
Brooks Air Force Base, TX 78235-5301

NOTICES

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This report has been reviewed and is approved for publication.

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The mission and organization of the United States Air Force School of Aerospace Medicine (USAFSAM) are discussed in an overview presented by the Vice Commander of USAFSAM.

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DEDICATED TO THE SELECTION, PROTECTION,

PERFORMANCE AND MAINTENANCE OF PEOPLE

IN THE AEROSPACE ENVIRONMENT

THE UNITED STATES AIR FORCE SCHOOL OF AEROSPACE MEDICINE

From a Taped Overview

Terry A. Benline, Colonel, USAF, BSC
USAFSAM Vice Commander

INTRODUCTION

Our business is conducted in three functional areas: science and technology, operational support, and aeromedical education and training. Although we are called the USAF School of Aerospace Medicine (USAFSAM), most of what we do is science and technology--about 70% of our manpower and about 85% of our budget are invested in science and technology. We do have an operational support role for the U.S. Air Force (USAF), and that role is primarily in aerospace medical education, hyperbarics, and epidemiology. And, of course, we have an educational facility, which is here to provide training in aeromedical specialties and subspecialties, rather than general medical education per se. The medical training for the USAF is provided at Sheppard Air Force Base in Wichita Falls, Texas--training, for example, the pharmacy technicians, laboratory technicians, and corpsmen who work on the wards. The flight surgeons, their technicians, the aerospace physiologists, the bioenvironmental engineers, and the medical support people who are more related to the operational USAF, are trained here at USAFSAM. Keywords;

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MISSION

The mission of the USAF School of Aerospace Medicine is to practice, teach, advance, and apply the principles of aerospace medicine. Aerospace medicine is a discipline in the Life Sciences which addresses the selection, protection, performance, and maintenance of humans in the aerospace environment.

Central to carrying out our functional responsibilities are ten product areas. Three of these areas relate to the operational support role, while six areas are primarily linked to the science and technology program. The remaining area, aeromedical education, is fundamental to about everything we do. Our products and services impact the USAF in three areas: crew protection and performance enhancement; occupational safety and health--making sure appropriate standards are being followed to protect the work force; and medical readiness--primarily in terms of combat casualty care and in aeromedical evacuation.

ORGANIZATION

Organizationally there are eight divisions. Three of the divisions are devoted to science and technology development (i.e., Clinical Sciences, Crew Technology, and Radiation Sciences). Three divisions are more aligned with the educational and operational support side of the house (Education, Epidemiology, and Hyperbarics). Each division derives funding from different sources. The operational support and education missions come to us from the USAF Surgeon General. These divisions provide services and support to the USAF at large. The work they do and the underlying science are allied to the medical and biomedical world and to the work we do in research and technology development. Our other major source of funding comes via the line and Major Force Program 6 which refers to the congressional account for doing research and development. In the eight major divisions within USAFSAM, six produce something in the way of products or services, and two provide support. Veterinary Sciences is a support division that is here because we perform animal research.*

*Q: Are there problems associated with using animals in research?
A: We are particularly aware that this is a highly divided and polarized issue; it would be difficult to change anyone's mind about this issue. One side of the community thinks it is absolutely essential to the advancement of biomedical or medical knowledge and understanding to do animal research. The other side of the community says that animal research is absolutely unnecessary and uncalled for. Those divergent views may never be brought together. Those of us who work in biological sciences believe that animal research is a valuable and a necessary tool for the advancement of science and the enhancement of the safety, health, protection, performance, and readiness of the United States Air Force. Our Veterinary Sciences Division maintains animal colonies according to standards set forth in the Animal Welfare Act, National Institutes of Health Policy, and USAF regulations. The animal program at USAFSAM has been fully accredited since May 1967 by the American Association for Accreditation of Laboratory Animal Care (AAALAC). All animal use protocols are scrutinized by the USAFSAM Animal Care and Use Committee before they are approved. When animals must be used for vital research and development, every effort is made to reduce the number of animals needed and to insure that pain and distress are eliminated or kept to an absolute minimum.

The Technical Services Division is the other support division. If I need help to manage the resources, or to manage a program, or to do the planning, this division provides the help. This division also provides support in logistics, audiovisual production, and fabrication of prototype equipment; they also manage the aeromedical library.

MISSION IN CONTEXT

One of the things I should point out is that we are not a separate island of capabilities; I think it is important for you to understand how we fit into the overall USAF structure at large, and how the process of systems development and acquisition works.

In the USAF structure, we are part of the Human Systems Division (HSD), and this division is part of the Air Force Systems Command (AFSC). The Human Systems Division has the responsibility for the science and technology development of systems that are relevant to selecting, assigning, integrating, protecting, and maintaining the human in the U.S. Air Force. The Human Systems Division has a number of laboratories; we are one of these laboratories. Within HSD there are three science and technology laboratories and two applications laboratories--the Air Force Drug Testing Laboratory (AFDTL) and the Air Force Occupational and Environmental Health Laboratory (AFOEHL). The AFDTL and AFOEHL take new knowledge and technology and apply them. In other words, they are not developers per se. On the technology development side, there is the Air Force Human Resources Laboratory (AFHRL) that does force management, that is, personal selection, classification and logistics research to improve support to the USAF maintainer out on the flight line with new technologies. This laboratory also does training research both for ground-based simulators and the classroom training environment, so that we can optimize that training and make it effective, and so we can understand what the ground-based simulator fidelity requirements are, and do the best job we can to transfer training from either simulator or classroom to the operational USAF. Then there is the Armstrong Aerospace Medical Research Laboratory (AAMRL) at Wright-Patterson Air Force Base (WPAFB), Ohio. This laboratory does biodynamics, bioengineering, human factors engineering, and toxicology research. They have a principal role in crew station design, optimizing human operator performance through improved coupling of the human-machine interfaces.

So what you are seeing today at USAFSAM is one-third of the laboratories that perform human systems science and technology development. If you've had experience with the Air Force before, you know that the USAF is typically organized into major commands, air divisions, wings, squadrons, and flights. AFSC is a major command, but it is not an operator; it is a systems developer for all of the Air Force. This command has product divisions, laboratories, ranges, and test centers. Air Force Systems Command represents, in terms of resources, about one-third of the business of the USAF. Developing and acquiring weapons systems are big business. It is costly, when you realize a B-1B costs in excess of $200 million. A lot of money is spent in building and developing these new weapons and systems. That's big business. When you think about it, though, the war fighting capability equation is a product of doctrine strategy, tactics, training, and systems. You can tweak all of these factors; you can fine tune the doctrine, the strategy, and the training; but I think we are pretty much up on the curve on all of these, on the asymptote as the scientist would say. It is new systems and their capabilities that really add punch to the war fighting equation, and that's what we're about, that's what we at AFSC are about. Now I am going to show you how that process works in a minute. In that context, we are not big business. The totality of our product division and the laboratories that I talked about within the HSD is about $410 million, only 1.5% of the AFSC total development and procurement budget. We're not a big player because we're not producing large systems like airplanes; typically we're involved in the subsystems development. We're not developing and building radars and global positioning systems or other kinds of large systems, those very expensive systems that other product divisions are involved with.

Now, let me show you where we are in the systems development and acquisition process. Most all of the human-centered work is in the exploratory development area. This area is a part of the acquisition process representing the flow of knowledge from science to hardware. You start with basic/fundamental research, and that research has an application; it's not just seeking knowledge for its own sake, but knowledge that we think is relevant to solving USAF problems. Next, we explore among potential technology alternatives, trying to find novel solutions to problems. We are drawing upon new knowledge that we've advanced in basic research and we are looking for promising alternatives, technology alternatives, that will ultimately result in some incremental improvement to our systems capabilities. Once we hone in on a promising alternative, and we want to refine it and demonstrate it, we begin to bend metal and build things. Therefore, most of the fundamental work involves paper studies, although you'll see some hardware that is being developed in the exploratory area. After this point, we want to demonstrate a technology and to prove the concept, we bend metal, but we are not overly concerned with engineering refinement at this stage of development. Beyond this advanced development or advanced technology transition and demonstration, we are handing materials off to a contractor, and sometimes the contractor refines it, engineers it, and delivers it to the USAF or we move it into what we call engineering development. That's where we prototype it, we demonstrate, validate and refine it more in what we call full-scale engineering development before we go into production. The product goes through developmental and operational test and evaluation, and ultimately is fielded. These steps are the process of systems acquisition. In that process, the work you will see here is in the area of basic research and exploratory development, and some work relating to technology demonstration.

Technology that comes out of this laboratory is today being refined to provide improved performance and protection to the operators of our weapons and supporting systems. This process is happening over in our product division, the Human Systems Division; and that is being done under contract to produce the systems. We work in this business day to day, and we sometimes lose sight of the fact that what we do is really very sophisticated--and the process itself is equally sophisticated.

HISTORY AND FACILITIES

Let me get back to the USAF School of Aerospace Medicine. You now know where we fit in this world of systems acquisition. An overhead view of the campus shows that the USAFSAM is literally in every building on the campus except building 140, which belongs to the AFOEHL.

The USAFSAM was built in the late 1950s and early 1960s. The complex represented the culmination of a number of school locations with historical roots tracing back to 1918, and a location at Hazelhurst Field in New York. The School moved to San Antonio, Texas, first to Brooks Field in the mid-1920s, in 1931, was transferred from Brooks Field to Randolph Field, Texas, and in 1959, back to Brooks Air Force Base. This complex was completed in the early 1960s. President John F. Kennedy came here in 1963 to formally dedicate these facilities in his last official act before he was assassinated in Dallas, Texas, the following day; so there is a memorial marker here that helps all of us remember the Kennedy presence and the presidential involvement in the creation of this important material asset. He talked about young Irish boys throwing their hats over the walls in Ireland as a parallel to the challenge of venturing into the unknown--a parallel to our early involvement with the manned space flight program. In those days, we were heavily involved in supporting the manned space flight program. Today we don't have this mission; however, we are doing some research of mutual interest between the USAF and National Aeronautics and Space Administration (NASA), such as pressure suits for high altitude protection and systems which protect aircrew members as well as space crew. We are mutually interested in research-like space adaptation, because it may be related to motion-induced sickness. Some of the research we do here may find application in the world of manned space flight, should we ever have a military presence in space.

We have a number of facilities in the outlying areas, for a variety of reasons, mostly availability of real estate. Replacement cost for all of our facilities and equipment representing 900,000 sq ft or 20 acres of floor space would likely approach $250 million.

RESOURCES

The USAFSAM total program represents approximately $30 million. About 85% of that or $26 million is spent in the research and development arena. The remainder, $4 million, reflects the operational and maintenance (O&M) account which sustains the operational support activities--epidemiology, hyperbaric medicine, dental investigations, aeromedical education, and training. About $13 million of that budget is spent in-house for salaries, equipment, supplies, etc., and in general to maintain the laboratories and many unique facilities. About $8 million is put on contract for work we cannot do in-house, or can be done better by an outside contractor. Included in our total funding are $5 million from a variety of external sources, virtually all of which is for research and development.

PEOPLE

There are about 850 people in USAFSAM, including approximately 390 enlisted, 150 officers, and 310 civilians. Seventy percent work in research and development; the remaining 30 percent are employed in the operational support areas. We have a much larger civilian contingent in our work force than what you will find in the USAF at large; that is because the nature of our work requires stability and continuity in the work force. Science and technology development takes time. Science and technology does not happen in days and weeks, but over years and decades.

We have approximately 300 degreed employees with about 200 professionals holding advanced degrees (100 Ph.D.s) and a number of people who are dual degree holders at the doctoral level. Our people have been recognized at the national level with committee appointments and numerous awards, both national and international, and election to key positions in their professional societies. A number of our people are consultants to the Air Force Surgeon General in their specialty areas. Our people represent a highly sophisticated, multidisciplinary team of medical, biomedical, and behavioral scientists. The hard physical sciences are represented by chemists, physicists, and the engineering disciplines. This blend of talent allows us to carry out our mission. We have a sophisticated group of technicians supporting the professionals in carrying out their work. We are not unlike a university, in the sense that we have laboratories and an educational program, and there is a synergy that exists, in that every single division in the USAFSAM is involved in education. And, as found at a university, our research efforts maintain technical/subject currency in our teaching role. Because people return here for educational update, there is vital information exchange wherein operational problems are brought back to the laboratories to ensure the proper focus and relevance to the work that we do. The people we train here belong to the medical community that directly supports flying operations. These trained people are not in the patient care business per se, but rather, they are out there working the flight safety issues, the environmental issues, etc. These trained people are more directly involved with the wing commander and the health and safety of his people in the USAF operations.

Some pilots and other aircrew members are trained by the School, but these are small numbers.

AIRCREW LIFE SUPPORT

Now I will walk you through the ten product areas. The aircrew life support area centers on a better understanding of the flight stress environment, i.e., how much altitude, how much acceleration, how much heat can the crew member tolerate--understanding the physiological mechanisms that relate to those kinds of stresses and oftentimes adverse environments--and then translating that knowledge into the protective equipment that is used to allow the aircrew member to cope with an expanding flight environment and foreign threat. If you want to fly higher, if you want to fly faster, and if you want to fly at higher turn rates, then you will need high technology protective systems. Humans have built-in physiological limitations, and we have to be able to counter those limitations; we do that by hanging a variety of equipment on the aircrew member, i.e., helmets, masks, G-suits, thermal cooling vests, etc. Much of our work involves tying our understanding of the flight stress physiology to the design of protective equipment--the hardware that is integral to the aircrew.

These examples are just some of the research we think exemplify our products--in the aircrew life-support area: We build electromechanical oxygen regulators because the current pneumatic systems create quite a bit of added fatigue. You must exert negative pressure on the mask to inhale and forcibly blow out to exhale, because respiration is dependent on pressure swings to operate the valves. When you are in the altitude chamber and put the mask on, you are going to find that it is not as easy to breathe with the mask on as it is to breathe ambient air without an oxygen mask.

The Advanced Technology Anti-G Suit (ATAGS) is a full coverage lower body pressure garment that is inflated when the crewmember encounters acceleration, elevates the heart and diaphragm with the abdominal bladder, and literally squeezes the lower extremities; it prevents the blood from pooling, but unlike the older models, which have individual upper and lower leg bladders, this new approach provides full coverage to the buttocks, legs, and feet, preventing the blood pooling, and aids in returning blood to the heart. The purpose and the effect are to supply enough blood, and with it oxygen, to the head to maintain vision alertness and consciousness during flight.

The Molecular Sieve Oxygen Generation System (MSOGS) technology is an engineering approach to extract oxygen from engine bleed air to avoid the logistics of oxygen supply. We have an onboard system that generates oxygen for the crewmember; it's called an On-Board Oxygen Generation System (OBOGS). The technology exploits the properties of zeolite crystals, adsorbing nitrogen, and freeing up oxygen. This system then uses pressure swing absorption to back flush the system to get rid of the nitrogen; it then reuses the same crystals to free up more oxygen for the crew.

There are other applications of OBOGS technology. The system may have a remote site application or field use where you need oxygen for medical treatment. You would then use a compressor out in the field, and use the MSOGS technology to provide purified oxygen, but those are developments that are downstream. We have a hot bench OBOGS system, and you can see it operating in the laboratory.

CREW PERFORMANCE

In this area, we are doing fundamental work in the sensory processing of information, both visual and vestibular sensory perception--understanding the sensory end organs in the inner ear and how these end organs sense motion cues. We are working to better understand the mechanisms that result in the spatial disorientation of pilots, which happens to be a significant cause of aircraft accidents, particularly at night and in weather operations. Our intent is to develop technologies or subsystems that will help combat the disorienting effects of flying at night, or in weather operations. We are looking at cues for acoustic orientation, where you would change the amplitude, pitch and lateralization of sound, in multidimensional space, to provide orientation cues. So you would have an additional cue that would be an auditory cue instead of the typical visual cues provided by looking at flight instruments or looking outside the aircraft. You would have a secondary source of information about aircraft attitude relative to the surface of the earth. You wouldn't just have to rely upon the outside visual scene content or viewing instruments, such as the attitude indicator and artificial horizon, for orientation--which, by the way, generate a significant workload.

We are active in looking at crew performance in systems like the Airborne Warning and Control System (AWACS) aircraft. These aircraft are equipped with long-range radar systems that the USAF uses to detect enemy intrusions of airspace and to provide command and control to the battlefield commanders. We are particularly concerned with team performance and crew performance in sustained operations as it relates to workload, fatigue, and performance degradation/enhancement. We are also interested in team interactions and team networking; how do you best extract the information from all the data sources, such as onboard sensors and remote sensors; how do you fuse it; how do you format it; how do you portray it so you can reduce the cognitive work load and provide information relevant to the task at hand, and at the same time reduce the extraneous information that is really not pertinent or necessary to performing a given task? These data are acquired using research simulators and trained aircrew members to assess their performance while they operate the simulator. Then we can propose changes in terms of crew duty schedules, procedures, the way the system is engineered, and the way it operates, so we can optimize individual/team networking and performance.*

In this area we are, for the most part, using the expertise of human factors engineering people to do the work. In other areas, medical, biomedical, and engineering people all work together under the aerospace medicine rubric in addressing a problem. An example is the area of spatial orientation. One aspect of spatial orientation, and one that I haven't addressed yet, is head-up display (HUD) design. The HUD is an optical combiner plate that is in front of the pilot, and the flight management data is presented on the HUD, so the pilot doesn't have to look down into the cockpit. He can see through it. In other words, it is transparent and the flight management data, the key parameters of airspeed, attitude, and altitude, are right there in front of the pilot. The pilot doesn't have to look down into the cockpit and is able to maintain a head-up orientation. If you are trying to design a HUD, you've got to have a blend of talent to address both medical and human factors issues. One of the ideas we are looking at is the pitch ladder. The pitch ladder displays the aircraft nose up/down situation. How do you best display

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*Q: How is the operation of Aerospace Medicine connected to what you just described?
A: It depends on the context in which you use the term aerospace medicine; we struggle with this ourselves. Clearly, there is certainly a neater connection between aerospace medicine and areas such as crew protection; I mean you are looking at flight stress, physiological effects and that sort of data. So, in the area of crew performance it is really the fundamental application of our knowledge of human sensory perception that is the link to aerospace medicine. You are looking at neurosensory processing, receptors, neural pathways, and brain functioning in the aerospace environment.

this information to get rapid assimilation of the information and the proper reaction? The visual system characteristics of the human also will, in part, drive the design of the pitch ladder. So, it really is a combined psycho-physiological, medical, human factors issue. That is why we need multi-talented people to solve such complex problems in the field we call aerospace medicine.

Clearly, there is a bottom line in all of this. It is human-operated machine performance that is the ultimate goal of most of this work. We view the human not as a limiting component, but as an enabler to make it happen. Since we don't have fully autonomous robots yet and since almost all machines have a human operator somewhere, even if the machine is remotely operated, you have a man in the loop, and the human enables you to carry out the mission.*

CHEMICAL DEFENSE

Now let me draw your attention to the chemical defense arena and the need to think about the foreign threat, in terms of chemical agents, and how we can operate in that environment, an environment which will be potentially contaminated by a variety of deadly agents. The issues in this area are individual protection and collective protection, meaning shelters for use as

*Q: Why don't we develop remotely controlled or autonomous weapons?
A: I don't think we fully understand how effective or ineffective the human is relative to a variety of sensors and the application of expert systems or artificial intelligence. For example, I don't know if an on-orbit thermal imaging sensor system for launch detection would be better than the man or not. The issue we are talking about is fully autonomous, intelligent machines. We are certainly some distance from solving all of the technological challenges in this area. On the other hand, we are beginning to exploit semiautonomous robotics. We like to think that the human is an enabler and not a limiter, and you are really getting me into USAF doctrinal and strategic issues in terms of how we would fight the next war and do we really need man in the loop. What is the mix of weapons and do we need more semiautonomous weapons? I would tell you that whether we use remotely piloted vehicles or manned aircraft, there is still a human in the loop somewhere; therefore, we are in that business of optimizing man-machine performance. There are still issues needing to be addressed. Frankly, there is the issue of recallability and we've always said and believed the strategic, air breathing bombers are a very important component of the strategic triad, because they are recallable.

rest stations, preparing people for return to battle, or as medical treatment stations, and either return combatants to battle, or put them into the air-evacuation system for transport to definitive care hospitals. Some of the other issues we are looking at besides chemical agent protection are warning devices and dosimetry. We are also interested in decontamination procedures: how do you remove the chemical agent and the suit from the person so that we can reduce the thermal burden and then decontaminate and treat the casualty? The suit is made essentially of rubber with charcoal-impregnated materials worn underneath it. We are also looking at the treatment of exposed casualties and performance degradation of our people exposed to chemical agents. We must also consider performance degradation, if a pretreatment drug is taken before exposure or an antidote medication is taken following exposure. We use pretreatment medications so that in the event of likely exposure, you can take a drug that presumably will reduce the ontoward effects of the exposure to the agent. We need to better understand what drugs to take; when to take these drugs and medications; what effects they will have on the crewmember. Will they be able to up-load weapons on the airplane, or to unload it, or to refuel it? Can the crewmember, the pilot, the ground support personnel carry out the mission? So we must understand the issues of protection; cooling, because the suits are hot; human performance, what happens to the pilot when flying the plane and exposed to chemical agents or protective medications.

COMBAT CASUALTY CARE

As I've suggested before, there is the whole issue of combat casualty care in a chemical environment. That means you have to have specialized equipment to assess the casualty's physical status. You can't use a standard blood pressure cuff and stethoscope to get at the blood pressure when the casualty has a rubber suit on. There are ways that we need to be able to test the vital signs of the casualty in this environment with full chemical gear on, and then, of course, we need to decontaminate them and get them into the shelters, and treat them. If they are not returned to duty, they are put into the air evac system. All of this equipment is specialized: monitors and ventilators, a variety of equipment used to treat a patient and their injuries during air transport. All of this equipment has to be airborne hardened and qualified. This equipment has to be electromagnetically compatible with other aircraft systems. The equipment must also withstand vibration, accelerations, impact, and pressure changes. A respirator that works in the hospital usually does not work very well on an airplane. So the respirator must be adapted and modified for the air evacuation mission. The goal of all this equipment is patient maintenance and survival until we can get to that 3rd or 4th echelon hospital where the patient will receive definitive medical care.*

RADIATION BIOEFFECTS

Moving your attention to radiation bioeffects technology, we look at radiation across the entire spectrum of electromagnetic energy from the radio frequencies to the microwaves, through the infrared to the visible, to include visible light as well as laser light and beyond the visible, to X-rays and gamma rays. We are not doing much work with ionizing radiation today because frankly, a lot of the work was done early because of our concern over nuclear and space radiation effects. We did a lot of studies, and we pretty much

*Q: How much waste is there in defense procurement?
A: We see the horror stories on procurement problems, and when you look at the complexity of what we do; when you look at the total investment in our national defense that goes into systems; and when you look at the dollar amounts that are involved; and when you put it in the perspective of the totality; we are talking about an extremely small percentage that surfaces in a negative way. These horror stories cause us great concern because they reflect negatively on the entire defense procurement and defense industry. We really think we do a pretty good job. If only a small fraction ends up being waste, that is not acceptable; but you still must put it in the context of the totality of our business which amounts to $100 billion a year across the three services. So it's a substantial level of activity, both by the government and by the aerospace industry, to produce and field complex and sophisticated weapons systems.

understand the cumulative dose effects and cumulative dose response relationships. We know how many times during war you can continue to regenerate a pilot and crew following exposure to given levels of ionizing radiation. So we've done most of that work. We still have a chronic radiation colony here which was proton irradiated to simulate long-term space radiation. This rhesus monkey colony is now 25 years postexposure and is providing valuable data on the long-term health effects of a variety of levels of ionizing radiation exposure.

The focus today is at the other end of the spectrum, the long radiofrequency wavelengths, the millimeter-microwave end of the spectrum in the kilohertz to the gigahertz frequency range. Most of this work involves energy bioeffects. Does the tissue heat up? Is it damaged without heating up? Are there cellular changes? Then, how do we translate this knowledge into appropriate exposure standards? We are constantly adding to the inventory of sensors, target designators and radars, such as the over-the-horizon backscatter radar that bounces a radar signal off the atmosphere and back to earth allowing us to detect incoming objects that are literally thousands of miles away. These sensor systems are often high energy sources, and we need to ensure the safety of the environment, understand the potential effects on human health, and ensure the safety of civilians living around our bases as well as the safety of our people working in the environment. Most of the work here relates to health and safety standards and to protection.

In the case of lasers, we are very interested in laser eye protection. That's really a knotty, challenging problem in the sense that we've got tunable lasers out there. When you start varying the laser's frequency, its pulse width, its amplitude, or intensity, you get differing effects. We are trying to get a better understanding of all these variances.

CLINICAL SCIENCES

In aerospace clinical sciences, we are the USAF Surgeon General's consultant for determining fitness for flying based on medical standards. About 600 to 700 aircrew members come to USAFSAM each year for a sophisticated medical evaluation, tests that are not widely or routinely available in our medical treatment facilities. As a result of this sophisticated examination, the crewmembers are either grounded or returned to flying status. Typically about 70% of the pilots are returned, sometimes under waiverable medical conditions, to flying status. These people are not sick; they are not the kind of people you would find walking through the door of a hospital. They are people who have subclinical or silent disease which we are concerned about because of the effects of flight stresses on certain disease conditions. About 60% of crewmembers are experiencing early forms of cardiovascular disease; they have some narrowing or blockage of blood vessels or some electrical signal abnormality. They are given treadmill tests, and radioactive thallium is injected to disclose diseased tissue in the heart. We have a freestanding cardiac catheterization laboratory; sometimes the heart is catheterized, providing pictures of the blood flowing through the coronary arteries. These pictures show definitively whether there is blockage.*

*Q: Are all of these people pilots and how many Air Force officers are pilots?
A: No, they are a variety of aircrew members. About two-thirds of the 600-700 aircrew members sent for evaluation are pilots. The Air Force has about 25,000 pilots. The medical data collected on these crewmembers is maintained in data repositories. We maintain the medical profiles on the evaluees for the duration of their careers. In some cases they come back to us, after retirement, so that we can follow them, and better understand the disease progression. Their medical profile is maintained as part of a study group. What that allows us to do is validate, reject, or modify our existing medical standards. It allows us at some point to determine who flew the most, the best, and the longest. Some fliers are grounded, but the medical community does not make that decision--Air Force wing commanders are the people who have that authority. Wing commanders exercise that authority based on medical recommendations. So, what we really are doing is providing a medical recommendation for a return to flying, or for a temporary or permanent grounding.

In terms of technology development, one of the things we are trying to do is to develop tools that are both more specific and more sensitive for a given disease. That's a tough issue to work, but we are developing increasingly sophisticated tools to get at disease that is asymptomatic and difficult to detect. The best example I can give you to illustrate the specificity/sensitivity problem is that if you are building a heat-seeking missile, and you make it increasingly more sensitive, so that it can detect smaller and smaller thermal gradients, the missile may eventually seek the wrong target. As missile target lock-on becomes more sensitive it will become less specific, and instead of attacking an airplane exhaust, it may attack the stars or the moon, or any other object which emits a small thermal gradient. The developers of medical diagnostic technology must also deal with this problem of specificity and sensitivity, and that is a tough issue. When you develop a very sensitive test you begin to lose specificity and you will punish more of the innocent; that is, you will end up inserting catheters and radioactive dye into people who do not have ischemic heart disease, a procedure that has some risks. Our approach to improved diagnostic techniques must try to avoid false positives and the occasional invasive testing of aircrew without disease, as well as false negatives (i.e., returning someone who really is at risk to flying duties).

EPIDEMIOLOGY

Our epidemiology service provides worldwide disease surveillance. This function is a one-of-a-kind service in the U.S. Air Force. They investigate new disease entities and outbreaks of disease, and they are involved in recommending the preventive measures to be taken against diseases likely to be encountered in worldwide military operations. There are new diseases that occur over time and new wrinkles in existing disease forms, and there is a need to better understand how diseases spread in a population. Our epidemiology function also provides specialized reference laboratory services, not for all lab tests, but certain tests which are very expensive or infrequently required; where it makes sense to have a centralized reference lab capability. Our medical treatment facilities submit specimens of a variety of body fluids and tissues for analysis, and the results are reported back to USAF medical facilities for these selected laboratory tests. We are responsible for the Air Force's Human Immunodeficiency Virus (HIV) screening program, more commonly referred to as acquired immunodeficiency syndrome (AIDS) testing. We do have in-house capabilities to perform AIDS testing, and we can run 9,000 - 12,000 specimens per month, but most of the testing is done under contract and we provide the quality assurance monitoring. We do track the results; in other words, we are interested in the epidemiology of the disease and the demographics of the infected population. It is a unique opportunity in the sense that our USAF population is demographically widespread. It is an opportunity to take a look at the epidemiology of the disease in a distributed population.*

We are also conducting the Air Force Health Study, sometimes called Ranch Hand. Ranch Hand refers to the USAF aerial spray operations in Vietnam where we sprayed the herbicide (Agent Orange) to control jungle vegetation, and, of course, some of our military personnel were exposed. Many of the Ranch Hands are 25 years postexposure, and we have approximately 1,000 Ranch Hands and 1,000 matched comparisons in the morbidity portions of the study. In mortality analysis, we have approximately 19,000 comparisons. The study requires

*Q: What is the Air Force policy on HIV testing positive for personnel?
A: We keep HIV positive airmen on active duty, health permitting. They are not discharged, but they are assigned limited duty. They are restricted from participating in jobs that require certain levels of personal reliability. They are evaluated every 6 months, to look at the disease progression. Their overseas assignment availability is totally restricted. They are kept on active duty until they are either retired normally or medically retired because of a deteriorating condition resulting from the disease.

regular physical checkups of the Ranch Hands and matched comparisons--both flightcrew and support personnel. To date, we have not found any significant differences in terms of disease or mortality in the exposed group which could logically be linked to exposure to Agent Orange or its dioxin contaminant.

Other epidemiologic studies, such as cancer cluster investigations, are routinely carried out. When there is an increased incidence of a certain type of disease, we are called to go in there and look at the population and exposure conditions to determine whether there is any epidemiological significance.

We also respond to outbreaks of mumps, measles, and influenza, by performing disease surveillance and recommending the proper immunizations to counter the most prevalent diseases.

HYPERBARICS

In hyperbaric medicine, we use compression chambers to treat a variety of nonhealing wounds which are not responding well to traditional surgical or antibiotic therapy. We use this procedure as an adjunct therapy. The patient is exposed in the chamber, usually to about 2-1/2 atmospheres of pressure. This pressure is the equivalent of 45 feet of seawater. They breathe 100% oxygen, usually in 30-minute intervals, with 10-minute rest periods in between. This treatment increases the tissue oxygen perfusion levels and promotes wound healing. Hyperbaric medicine is used to treat problems like gas gangrene, and chronic osteomyelitis, difficult nonhealing wounds caused by a bacterium. We also use it to treat patients who have been exposed to radiation therapy and where the healthy tissue, as well as the diseased tissue, has been damaged. What we are trying to do is to promote the development of healthy tissue. What seems to result is improved blood and oxygen supply to the affected area.

We are also looking at it clinically, for treatment of burns, crush injuries, diabetic wound healing, and other applications. We perform clinical trials to assess its efficacy in a more scientific way, in concert with using hyperbaric oxygenation for patient treatment.

Historically, the chambers go back to our interest in treating decompression sickness, or aviators' bends, and in time we've evolved the other medical applications. This method of treatment is also used on an emergency, life-threatening basis to treat carbon monoxide exposure because you can reduce the half-life of carbon monoxide in the body using high-pressure oxygenation.

DENTAL INVESTIGATIONS

In the dental investigation area, we have a group of people that help our USAF dental service, by testing and evaluating tools, techniques, procedures, and facilities design, so that we can do the very best in terms of the quality of the dental care provided--such things as the effectiveness of the procedures, or how can we ergonomically design the dental equipment so we can accommodate the left-handed or right-handed dentist. There are also combat applications--the surgical field unit is portable so you can set up a dental clinic under austere environmental conditions and perform dental surgery. During wartime there are going to be jaw injuries, displaced teeth, and simple toothaches. We try to make sure our people are fit and ready for combat, by providing routine dental checkups and care, but there will be dental emergencies in wartime, resulting from combat injuries that will require oral surgery and other types of dental care.

Most of the items in the dental service are centrally procured, and somebody has to select among the available items in terms of quality and cost, and our people make these kinds of recommendations to the Air Force Dental Surgeon.

AEROMEDICAL EDUCATION

The last area, and really the cornerstone of the USAF School of Aerospace Medicine, and the historical reason for the importance of the word "school" in our name, is the aerospace medical education program. We train about 5,000 people per year. This training is conducted for all of the entry level aeromedical specialties, meaning new people coming on board. We also provide specialized training, usually at the graduate level, for flight surgeons, flight nurses, bioenvironmental engineers, aerospace physiologists, and environmental health officers. As I mentioned earlier, there is certainly a very important synergy between the school, the research, the operational support, and all of the things we do here. You can take any area that we've talked about, any of these product areas, and find linkages and interconnects. For example, we continually return people to participate in aeromedical training with an operational focus, and we provide for upgrade and refresher training for aerospace medical and allied professionals. When these people come back, they return for additional training like global medicine. Well, if you are going to teach global medicine, obviously you want to teach them something about what is happening out there with dengue fever, Japanese encephalitis, and on and on. Our epidemiology people come in and help teach the global medicine course. That loop we talked about, bringing the operational problems to the scientist and the engineer, as well as the scientist and engineer providing currency of information in our academic programs, really is a university model that has worked very well for the USAF School of Aerospace Medicine, and more importantly, for the U.S. Air Force in providing for education of our aeromedical talent pool. Equally important, it has provided a proper focus for our research and technology development programs.

CONCLUSION

I think you can see from this overview that the USAFSAM mission represents the spectrum of selecting, protecting, integrating, and maintaining people in Air Force operations!

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